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Space Communication and Navigation (SCaN) Payload

Results and Applications Session

CNES-NASA Disruption-Tolerant Networking (DTN) Interoperability

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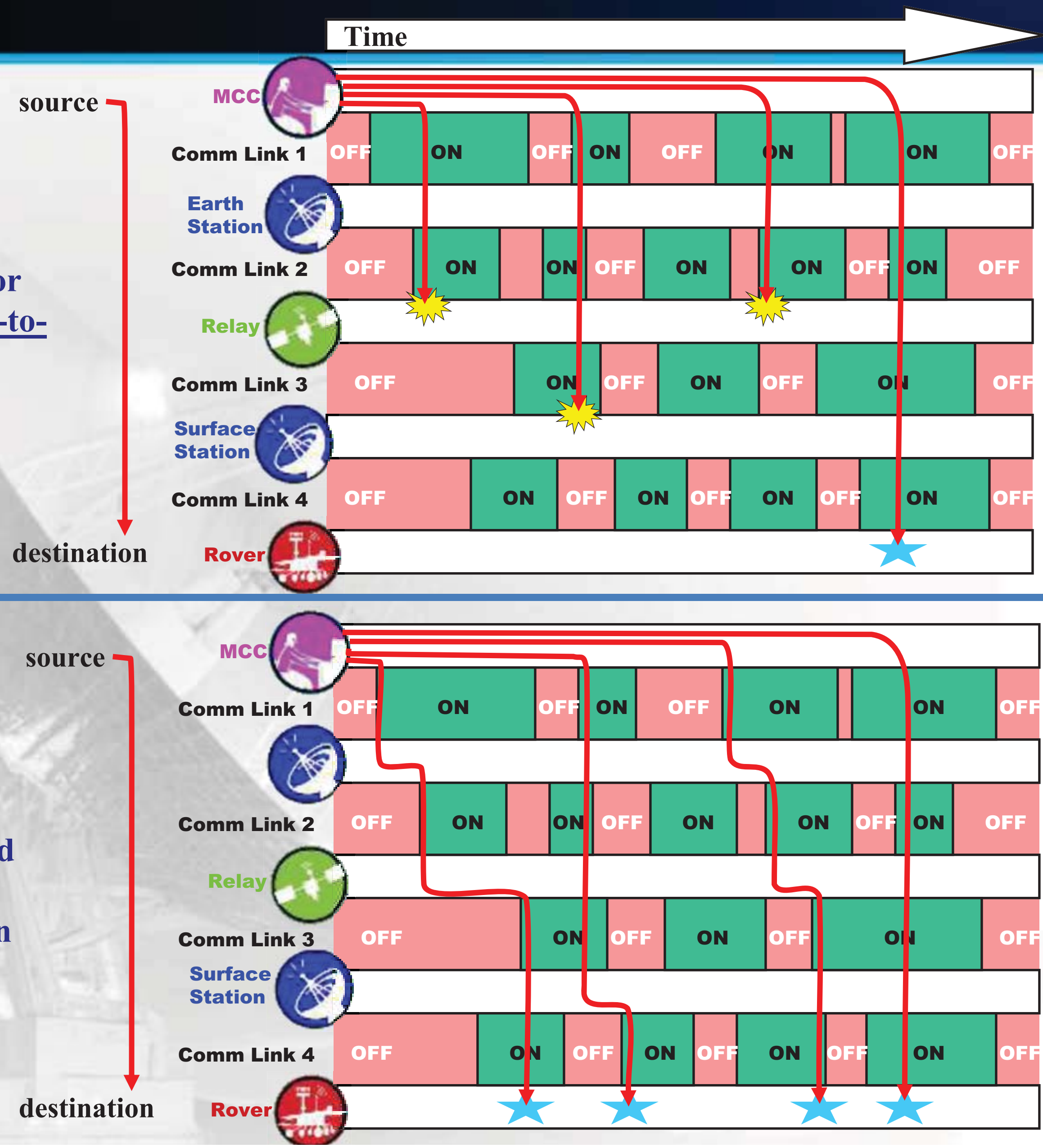
Overview

- NASA and CNES are working together to use the SCaN Testbed to prepare for future “space internetworking” services

- This involves use of Disruption-Tolerant Networking (DTN) as a network layer to support CCSDS* File Delivery Protocol (CFDP) over CCSDS space links and a legacy CCSDS ground segment

***CCSDS = Consultative Committee for Space Data Systems*

Disruption Tolerant Networking (DTN)



Without DTN:
User must wait for a continuous end-to-end path.

Data are discarded by IP routers if next hop is not available

One dataset, repeat attempts

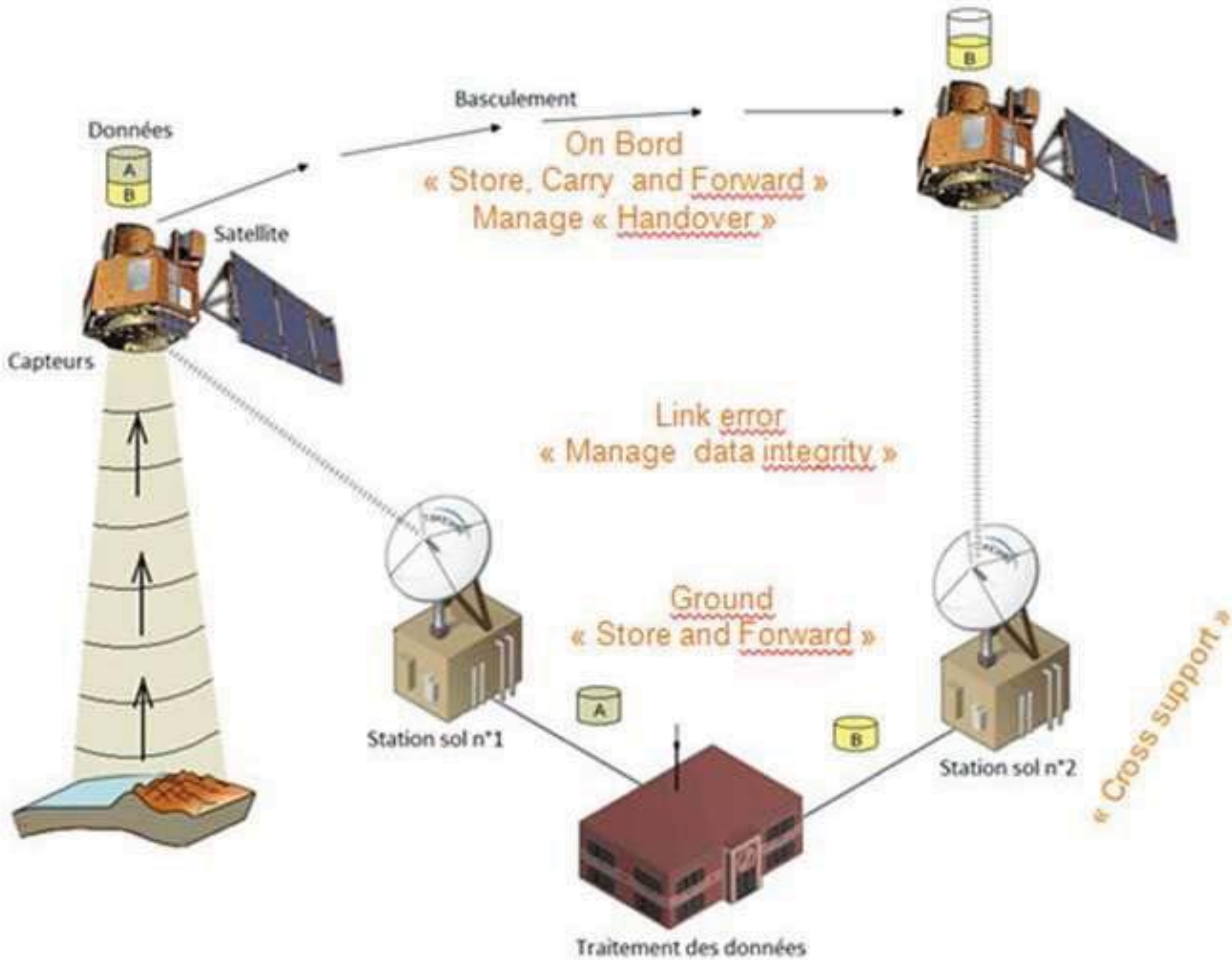
With DTN:
Data are held at DTN routers and continue to destination when next hop is available.

In stressed communications environments:

Increased VOLUME of data, delivered FASTER, i.e. higher GOODPUT and lower LATENCY

Four datasets

CNES Use Case



Experiment Objectives

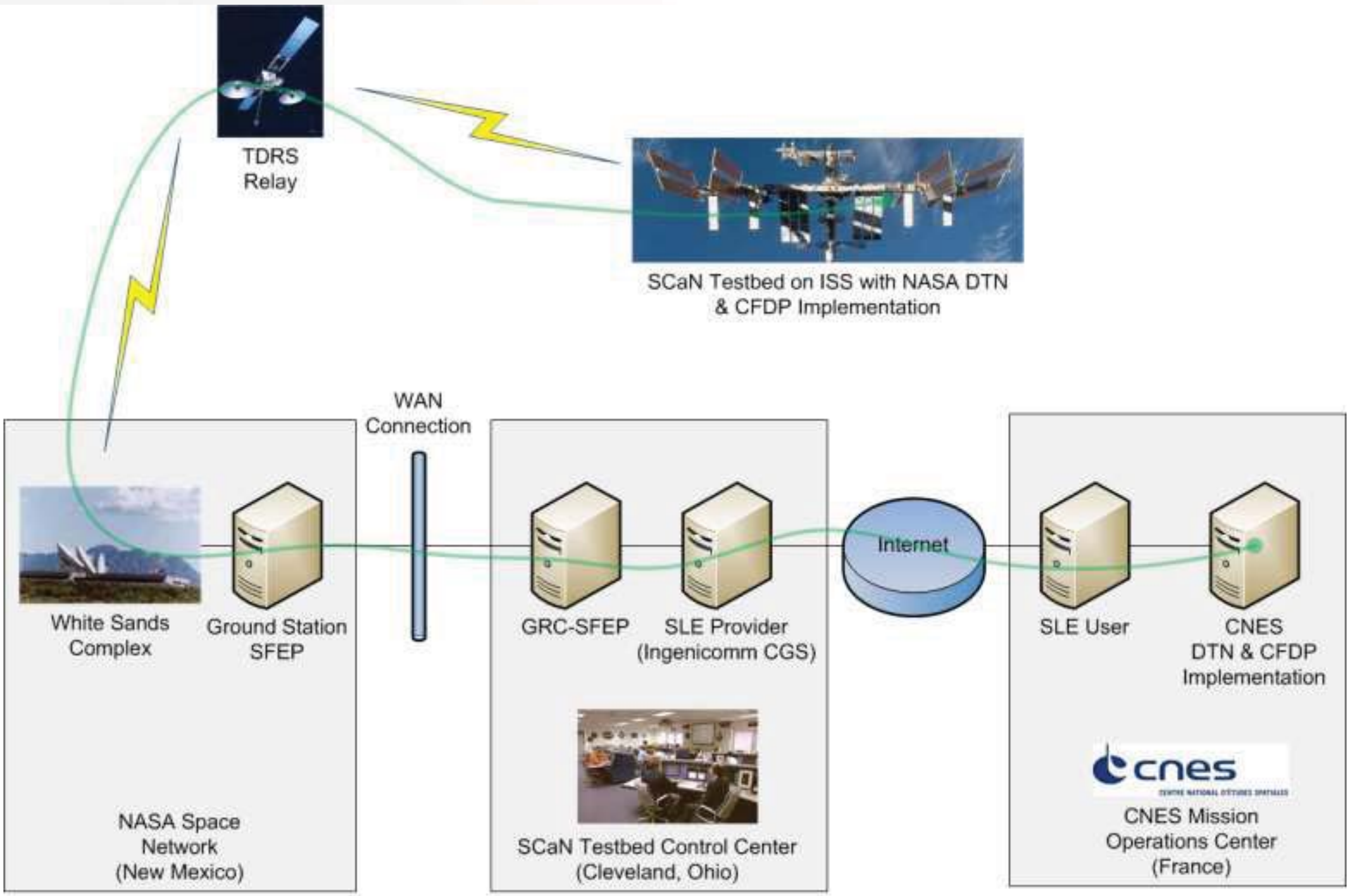
1. Standardize and secure large file downlink operations over legacy ground infrastructure
2. Make robust and efficient use of the space link for mission data dumps, applicable to future high-rate Ka-band and optical links
3. Enable transparent cross support operations with other space agencies using DTN over existing SLE infrastructure
4. Refine concepts of operations for future space internetworking services and inter-agency routing of data

Major Additions to SCaN Testbed

- Internet connectivity for experiment data transfer √
  - Using CCSDS Space Link Extension (SLE) protocol
  - Offers capability for remote experimenters to use the on-orbit resources
- Store-and-forward operations and routing of data
  - Using CCSDS DTN Bundle Protocol (BP)
- Reliable transfer over high-delay error-prone links
  - Using CCSDS DTN Licklider Transmission Protocol (LTP)

These are implemented as capabilities that can be used by future SCaN Testbed experiments on the ISS

End-to-End Data Flow

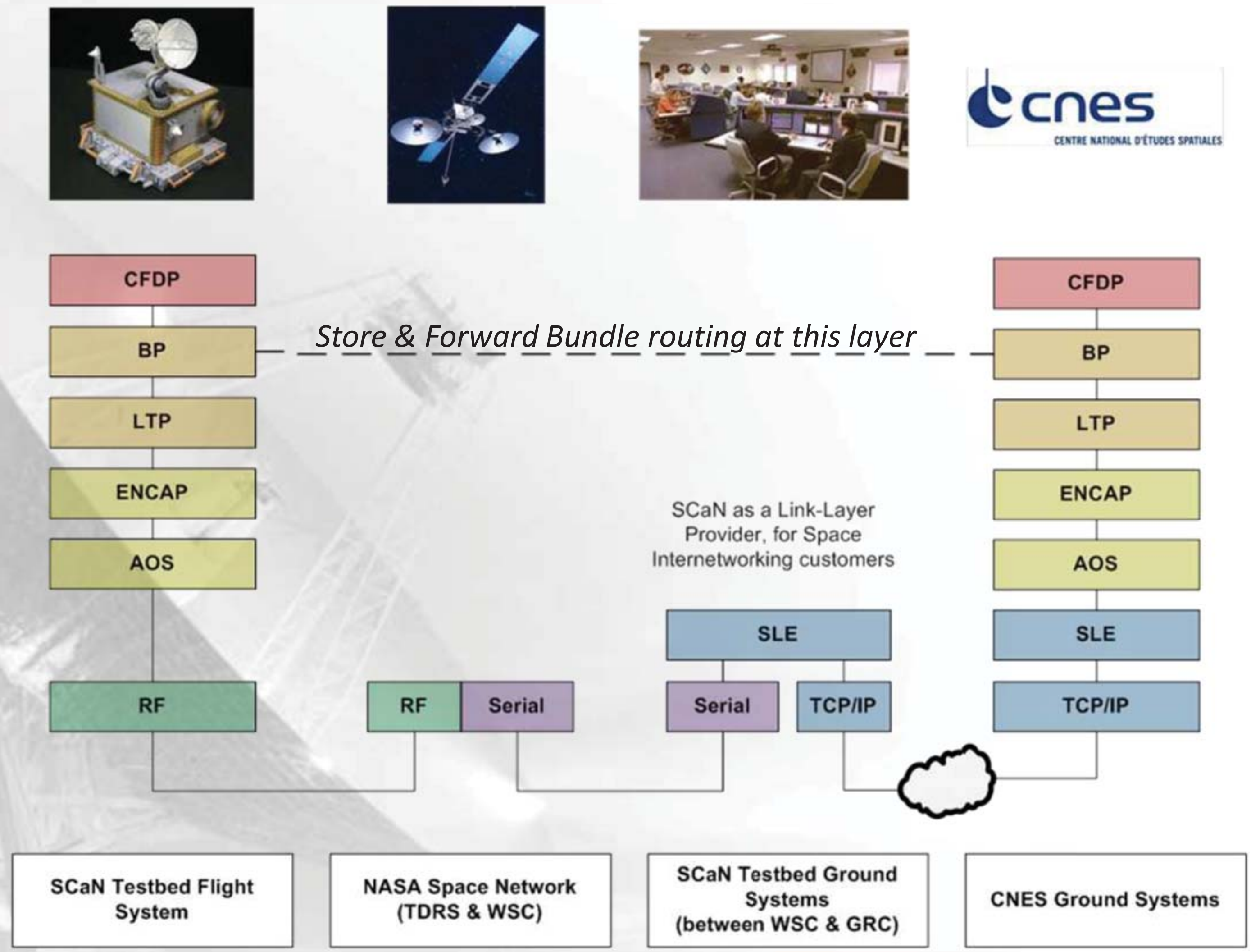


End-to-end data flow between CNES and NASA's ground and space assets using space internetworking protocols

Protocol Stack Toolbox

CFDP	CCSDS File Delivery Protocol – File transfer application between space and ground systems
BP	CCSDS Bundle Protocol – Store-and-forward network relay protocol
LTP	CCSDS Licklider Transmission Protocol – Retransmission protocol for repairing losses over long-delay space links
ENCAP	CCSDS Encapsulation Protocol – Supports generic encapsulation of higher-layer protocols in CCSDS frames
AOS	CCSDS Advanced Orbiting Systems – Framing protocol for space links
SLE	CCSDS Space Link Extension – Relays frames between ground systems operated by mission users and space communications service providers
TCP/IP	Internet Transmission Control Protocol and Internet Protocol – Provide reliable delivery of data between terrestrial applications

Protocol Stacks



Flight Implementation Approach

- DTN protocols are implemented in the SCaN Testbed avionics flight computer
  - This allows all 3 software defined radios to be used
- Integrated code from multiple sources:
  - Interplanetary Overlay Network (ION) open source software available on the web provides:
    - CFDP, BP, LTP
    - ION was modified to run on our version of the VxWorks operating system, and to support interface with ENCAP driver provided by SCaN Testbed Experiment #3
  - SCaN Testbed Experiment #3 (IP over CCSDS) implemented custom VxWorks software for ENCAP, AOS, and the SpaceWire interface onboard

Unique Aspects

- Uses LTP natively over CCSDS space links
  - More efficient stack than some previous CFDP/DTN work (e.g. DINET/EPOXI)
- Uses DTN over an SLE-based ground network
- Uses DTN BP & LTP protocols over Ka-band space links
- Creates a lasting DTN capability for other ISS / SCaN Testbed work
  - Uses latest ION software distribution
  - Software on flight and ground nodes can be reconfigured and evolved

Importance to NASA/SCaN

- Enable transparent cross support operations with other space agencies using DTN over existing SLE infrastructure
  - SCaN can support missions using advanced space internetworking protocols while itself only providing a link-layer service comparable to the current capabilities of DSN, SN, and NEN
- Refine concepts of operations for future space internetworking services and inter-agency data routing
- Make robust and efficient use of the space link for mission data dumps, applicable to future high-rate Ka-band and optical links

Future Work

- Adaptive/Cognitive concepts
  - Integrating various network layers, sharing status and control information so that learning can improve system-wide performance
  - VCM and ACM experiments planned
  - Adaptive routing research

Contact Info

SCaN Testbed website:

http://spaceflightsystems.grc.nasa.gov/SOPO/SCO/SCaNTestbed/

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